Dysphagia characterized by aspiration subsequent to pontine stroke

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It has been reported that a pontine lesion often results in dysphagia characterized by aspiration. However, the patterns and characteristics of such dysphagia are unknown. We studied 57 patients (34 men, 23 women) with possible dysphagia consequent to pontine stroke. We compared the aspiration characteristics with three different pontine lesion loci (e.g., unilateral, bilateral, and pontine-plus group). Fifteen of 57 patients (26.3%) aspirated upon a spoonful quantity of barium. All 15 aspirators had either a bilateral pontine or pontine-plus lesion. Nine of the 15 (60%) aspirators were "silent" aspirators as revealed in the VFS studies. The conclusion to be drawn from this study is that, unlike the widespread belief, aspiration symptom due to an isolated unilateral pontine infarction may be uncommon and transient.

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Dysphagia may be manifested in several forms. Among them is *aspiration* defined as the tracheal invasion of foreign material or saliva below the true vocal folds (Logemann, 1998). Aspiration itself can be seriously detrimental to stroke patients due to its apparent sequela, aspiration pneumonia. Its risk may further rise with "silent" aspiration upon which a patient may not be conscious of the tracheal invasion and thus fails to manifest protective reactions such as coughing, throat clearing, and the like. Thus, silent aspiration can only be detected by an instrumental tool such as videofluoroscopic swallowing (VFS) study or fiberoptic endoscopic examination of swallowing evaluation.

Dysphagia is a common consequence of stroke in the brain stem, including medulla oblongata and pons (Caplan & Han, 1995; Horner et al., 1991; Kim et al., 2000). It has been well known that a swallowing center is situated in the medulla oblongata (Jean, 1984; Jean, Car, & Roman, 1975) and consequently its lesion can be unfavorable to normal swallowing functions. Further, pons as a connected swallowing pathway with medulla is also an important structure for swallowing function in a coherent manner (Kessler & Jean, 1985). It is common to observe dysphagia as a clinical finding of a large bilateral infarct and a pontine hemorrhage (Horner et al., 1991). In a clinical situation, however, patients with even a relatively small pontine lesion also may report swallowing difficulties manifested as intermittent invasion of food into the airway resulting in throat clearing or coughing. In this regard, a guideline in the decision-making process is necessary because a clinician needs to pursue an immediate, alternative feeding mode such as a nasogastric (NG) tube.

To our knowledge, dysphagia due to pontine lesions has received relatively little attention. Although Horner et al. (1991) investigated 23 subjects with brain stem stroke, the patient group was rather heterogeneous in terms of the nature of the lesion. Of their 23 subjects, there were only 5 patients with pontine-focused lesions and 8 with concomitant cerebellar lesions. The remainder had brain stem lesions elsewhere such as in the medulla oblongata or midbrain.

The underlying neurophysiological causes of aspiration are multifaceted, given that both reduced functions in the oral mechanism, and pharyngo-laryngeal abnormalities also may result in tracheal invasion by foreign material under the vocal folds. Thus, it may be of interest to investigate the extent of a neurological lesion that relates to the dysfunction of oral and pharyngo-laryngeal swallowing mechanisms associated with aspiration by pontine stroke patients.

This study aimed to investigate the relationship between the extent of a pontine lesion and aspiration. Improved understanding of the association will increase the knowledge of neuropathophysiology as it concerns poststroke outcomes, thereby facilitating more efficient use of health resources for this patient group.

PATIENTS AND METHODS

Subjects

One hundred-seventeen consecutive patients with pontine stroke and consequent dysphagia were referred over a 6-year period to the Speech & Swallowing Clinic of the Department of Neurology at a tertiary-care university medical center. The inclusion criteria of patients were to include those with (a) stroke at pontine area; (b) recent MRI results; (c) no previous strokes in other brain areas than pons; and (d) no other concomitant neurological diseases. Of the 117 patients, therefore, the following 60 patients were excluded from the patient-pool, reducing the number of subjects into 57 patients:

1. 4 patients with extensive time-gap between radiographical studies and the VFS studies;
2. 22 without radiographical results;
3. 31 with previous stroke episodes;
4. 1 diagnosed with Guillain-Barré syndrome six years before the left pontine infarction;
5. 1 with 7 years of epilepsy history; and
6. 1 with a tracheostomy tube.

The tracheostomy tube has been reported to exert a negative effect on swallowing (Eibling & Gross, 1996). In the 57-patient pool, we included 9 patients with new pontine lesions in addition to previous history of stroke in the pons. As shown in Table 1, the subject group consists of 34 men and 23 women of ages ranging from 42 to 92 years (Mean: 67.2; SD: 9.7).

Data Collection and Analysis

Neurological Lesion and Neurofunction

The lesion location and extent were determined by two neurologists (YK & CC) based on the brain MRI (MR/Genesis-Signa) results. The two investigators were blinded to the clinical information and

TABLE 1. Clinical data of 57 patients with pontine lesions.

Lesion Group*	Patient No.	Sex/ Age	Type of Lesion†	Side of Lesion‡	POT at First Exam§	Loci of Concomitant Lesion‖	Facial Palsy (0, 1)◇	Dysarthria (0–4)⊙
Uni-	1	M/50	H	L	5	-	1	2
Uni-	2	M/71	I	L	5	-	1	1
Uni-	3	M/60	I	L	7	-	1	3
Uni-	4	F/61	I	L	7	-	1	2
Uni-	5	M/69	I	L	4	-	1	2
Uni-	6	F/60	I	L	5	-	0	2
Uni-	7	M/65	I	L	8	-	1	1
Uni-	8	M/65	I	L	5	-	1	3
Uni-	9	F/57	I	L	2	-	1	3
Uni-	10	F/81	I	L	4	-	1	0
Uni-	11	F/69	I	L	4	-	1	1
Uni-	12	M/76	I	L	5	-	1	0
Uni-	13	M/67	I	L	11	-	0	1
Uni-	14	M/69	I	L	30	-	1	1
Uni-	15	F/71	I	L	2	-	1	1
Uni-	16	M/63	I	L	6	-	0	1
Uni-	17	M/79	I	L	7	-	1	1
Uni-	18	F/69	I	L	4	-	0	2
Uni-	19	F/92	I	L	18	-	1	1
Uni-	20	F/88	I	L	9	-	1	2
Uni-	21	M/58	I	L	9	-	1	1
Uni-	22	F/62	I	L	4	-	1	3
Uni-	23	M/64	I	L	3	-	1	1
Uni-	24	M/84	I	L	13	-	1	0
Uni-	25	F/73	I	L	2	-	0	1
Uni-	26	M/63	I	R	5	-	1	1
Uni-	27	F/63	I	R	3	-	1	0
Uni-	28	F/64	I	R	10	-	1	3
Uni-	29	M/63	I	R	2	-	1	3
Uni-	30	F/64	I	R	8	-	1	1
Uni-	31	M/76	I	R	7	-	1	1
Uni-	32	F/76	I	R	1	-	1	1
Uni-	33	F/71	I	R	8	-	1	1
Uni-	34	M/70	I	R	5	-	1	0
Uni-	35	M/50	I	R	2	-	0	0
Uni-	36	M/72	I	R	2	-	1	0
Uni-	37	F/70	I	R	10	-	1	0
Uni-	38	M/56	I	R	8	-	1	0

TABLE 1. *(continued).*

Lesion Group*	Patient No.	Sex/ Age	Type of Lesion†	Side of Lesion‡	POT at First Exam§	Loci of Concomitant Lesion‖	Facial Palsy (0, 1)◇	Dysarthria (0–4)⊙
Bi-	1	M/54	H	Bi	10	-	1	2
Bi-	2	M/43	H	Bi	8	-	1	2
Bi-	3	M/59	I	Bi	17	-	1	4
Bi-	4	M/78	I	Bi(R→Bi)	10	-	1	3
Bi-	5	M/70	I	Bi(R→L)	10	-	1	2
Bi-	6	F/64	I	Bi(R→L)	30	-	1	3
Bi-	7	F/60	I	Bi(L→R)	2	-	1	2
Bi-	8	M/60	I	Bi(L→R)	10	-	1	2
Bi-	9	M/70	I	Bi(R→L)	3	-	1	1
Bi-	10	M/70	I	Bi(L→R)	35	-	1	2
Bi-	11	M/73	I	Bi(L→R)	5	-	0	2
Pp	1	F/77	I	L	4	Bi. WM	1	1
Pp	2	M/69	I	L	9	Bi. Cbll	1	3
Pp	3	F/75	I	L	8	L. Cbll	0	1
Pp	4	M/64	I	R	10	Bi. Cbll	1	3
Pp	5	F/72	I	Bi	13	Bi. WM	1	2
Pp	6	M/76	I	Bi	10	Bi. PV, WM	1	3
Pp	7	F/71	I	Bi(L→R)	1	Bi. PV, WM	0	3
Pp	8	M/42	I	Bi	7	Bi. PV, WM, Cbll	1	2

* Uni- indicates unilateral; Bi-, bilateral; and Pp, pontine-plus.

† I indicates infarction; and H, hemorrhage.

‡ L indicates left; R, right; and Bi, bilateral.

§ POT indicates postonset time.

‖ WM indicates white matter; Cbll, cerebellum; and PV, peri-ventricle.

◇ 0 indicates normal; and 1, abnormal.

⊙ 0 indicates normal;1, midly abnormal; 2, moderately abnormal; 3, severely abnormal; 4, profoundly abnormal.

the swallowing patterns of each patient. When any concomitant lesion was not found, the isolated pontine lesion was identified as either unilateral or bilateral. The areas of concomitant lesions were categorized as periventricular (PV) area, white matter (WM), and cerebellum (Cbll). Two neurofunctional variables, facial palsy and dysarthria, were analyzed in this study because they would most likely be related to pontine lesion (Hopf et al., 1990; Kim, 2002; Teasell et al., 2002). The presence of dysarthria as an articulatory impairment rated as 0–4 (0 being normal, 4 being profoundly impaired) was evaluated by a speech-swallowing specialist (HK). The interval rating scale was used for the dysarthria rating because it is conventionally utilized by speech-language pathologists during speech evaluations. Facial palsy was diagnosed as being either present (= 1) or absent (= 0). Only presence of facial palsy was determined as neurologists utilize the protocol during neurological examinations. Eighteen out of 57 (31.6%) patients visited other hospitals prior to the admission to the tertiary-care university medical center, resulting in a longer overall time gap between the disease onset and the initial evaluation. The average post onset time at the time of the initial evaluations was 8 days.

Swallowing

The speech-swallowing specialist, HK, performed the VFS studies. Each patient was situated in a commercially available VESS chair for the VFS studies. The protocol of a spoonful (5 ml) and a drinking cup (8 oz) of thin liquid barium was administered to each patient. The instruction given to each patient was, "Hold the barium until you are told to swallow." As we fed the barium to the patients, the lateral view from the anterior nasal spine to the cervical vertebrae was obtained. We also recorded the anterior-posterior plane to observe asymmetrical functions of pharyngo-laryngeal structures. We investigated the bolus-dependent outcome, aspiration because it is thought to be clinically significant. The results of the VFS studies were dichotomized into aspirated swallowing and nonaspirated swallowing. It was determined as aspiration if the clinician observed tracheal invasion of barium below the true vocal folds. Further, silent aspiration was confirmed if a subject demonstrated no signs of awareness of the tracheal invasion of barium.

RESULTS

As shown in Table 1, three lesion groups were formed: unilateral lesion, bilateral lesion, and pontine-plus lesion. The unilateral lesion group includes patients with either left or right lesion at the pons. The bilateral lesion group consists of those with left as well as right pontine lesions regardless of the sequence of strokes. Pontine-plus lesion group refers to the patients with other supratentorial and/or infratentorial lesions in addition to pontine lesion.

Thirty-eight out of our 57 (66.7%) patients presented an isolated unilateral pontine lesion. Eleven out of 57 (21.1%) patients had a bilateral isolated pontine lesion. The remaining 8 (12.3%) patients had other brain lesions in addition to the pontine lesion.

Of 57 patients, nearly a half of the patients (i.e., 28 patients, 49.1%) had lesions in the left pons. Fourteen (24.6%) had lesions on the right, and 15 (26.3%) bilaterally. Nine patients had two consecutive pontine stroke episodes. The lesion sides of each stroke episode for the patients are characterized as following: 5 patients (left, then right), 3 patients (right, then left), and 1 patient (right, then bilateral).

Table 2 shows that 15 of the 57 (26.3%) patients exhibited aspiration upon consumption of a small quantity of barium. Five patients were added (thus 20 patients, 35%) in the aspirator group upon a large quantity of barium intake. The mean postonset days at the time of the initial evaluation for aspirators and nonaspirators were 9.9 days and 6.9 days, respectively. Eleven of 20 (55%) aspirators were silent aspirators. None of 57 patients demonstrated absent swallowing response. Forty-eight (84%) patients exhibited dysarthria characterized by imprecise articulation. Table 3 shows the aspiration rate of each lesion group. Fisher's exact test revealed that rate of aspiration upon a spoonful feeding of barium was different in three lesion groups [χ^2 (2, N = 57) = 42.303, p = .000]. In the following, we specified aspiration characteristics of the three lesion groups.

Unilateral Isolated Pontine Lesion Group

Thirty-eight (66.7%) of 57 patients had the unilateral isolated pontine lesion. As seen in Figure 1 of the radiographic result of this group, 25 out of 38 (65.8%) patients with the unilateral lesion had left side, and 13 (34.2%) had right side lesions. None of these 38 patients exhibited any aspiration symptom after the small amount of liquid feeding. However, 4 of 38 unilateral patients exhibited either silent (2 patients) or symptomatic (2 patients) aspiration upon a large quantity of barium consumption. Initial feeding modes at the time of the first evaluation were NG tube feeding for 11 patients and oral feeding for the remaining 27 patients.

Among 38 unilateral pontine lesion patients, 29 (76.3%) exhibited a diverse degree of dysarthria. Seventeen (58.6%) of 29 patients exhibited mild (rating scale = 1) dysarthria. Each of six (20.7%) patients showed either moderate (rating scale = 2) or severe (rating scale = 3) severity of dysarthria. None showed anarthria (i.e., profound severity of dysarthria, rating scale = 4). Recommended rehabilitation method for this patient group included oral-only feeding or additional diet modification (DM)/postural modification (PM).

Bilateral Isolated Pontine Lesion Group

Eleven (19.3%) out of 57 patients had bilateral isolated pontine lesions. Figure 2 shows the radiographic results of this bilateral lesion group. Among 11 patients with the bilateral lesions, 9 (81.8%) patients exhibited aspiration symptoms upon consumption of even a small quantity of liquid barium. Five of 9 (55.6%) patients manifested

TABLE 2. Information on initial feeding mode, aspiration, and recommended feeding mode.

Lesion Group*	Patient No.	Initial Feeding Mode†	Aspiration on Spoon Feeding (Silent?)‡	Aspiration on Cup Drinking (Silent?)‡	Recommended Feeding Mode After VFS Study§
Uni-	1	Oral	0	1(1)	Oral feeding + DM
Uni-	2	Oral	0	0	Oral feeding
Uni-	3	Oral	0	0	Oral feeding
Uni-	4	Oral	0	0	Oral feeding + DM
Uni-	5	Oral	0	0	Oral feeding
Uni-	6	Oral	0	0	Oral feeding
Uni-	7	Oral	0	0	Oral feeding + DM
Uni-	8	Oral	0	1(0)	Oral feeding + PM
Uni-	9	NG tube	0	0	Oral feeding
Uni-	10	Oral	0	0	Oral feeding
Uni-	11	Oral	0	0	Oral feeding
Uni-	12	NG tube	0	0	Oral feeding + DM
Uni-	13	Oral	0	0	Oral feeding
Uni-	14	Oral	0	0	Oral feeding
Uni-	15	Oral	0	0	Oral feeding
Uni-	16	Oral	0	0	Oral feeding
Uni-	17	NG tube	0	0	Oral feeding
Uni-	18	NG tube	0	0	Oral feeding
Uni-	19	NG tube	0	0	Oral feeding
Uni-	20	Oral	0	0	Oral feeding
Uni-	21	NG tube	0	0	Oral feeding
Uni-	22	NG tube	0	0	Oral feeding
Uni-	23	Oral	0	0	Oral feeding
Uni-	24	NG tube	0	0	Oral feeding
Uni-	25	Oral	0	0	Oral feeding
Uni-	26	Oral	0	0	Oral feeding
Uni-	27	Oral	0	1(1)	Oral feeding + DM
Uni-	28	Oral	0	0	Oral feeding
Uni-	29	Oral	0	0	Oral feeding
Uni-	30	NG tube	0	0	Oral feeding
Uni-	31	Oral	0	0	Oral feeding
Uni-	32	Oral	0	0	Oral feeding
Uni-	33	NG tube	0	1(0)	Oral feeding + DM
Uni-	34	Oral	0	0	Oral feeding
Uni-	35	Oral	0	0	Oral feeding
Uni-	36	Oral	0	0	Oral feeding
Uni-	37	Oral	0	0	Oral feeding
Uni-	38	NG tube	0	0	Oral feeding

TABLE 2. *(continued).*

Lesion Group*	Patient No.	Initial Feeding Mode†	Aspiration on Spoon Feeding (Silent?)‡	Aspiration on Cup Drinking (Silent?)‡	Recommended Feeding Mode After VFS Study§
Bi-	1	NG tube	1(1)	*np*	NG tube feeding
Bi-	2	Oral	0	0	Oral feeding
Bi-	3	NG tube	1(0)	*np*	NG tube feeding
Bi-	4	NG tube	1(0)	*np*	Oral feeding + DM + PM
Bi-	5	Oral	1(1)	*np*	Oral feeding + DM
Bi-	6	NG tube	1(0)	*np*	Oral feeding + DM + PM
Bi-	7	NG tube	1(0)	*np*	NG tube feeding
Bi-	8	NG tube	1(1)	*np*	NG tube feeding
Bi-	9	NG tube	1(1)	*np*	NG tube feeding
Bi-	10	Oral	0	1(0)	Oral feeding + DM + PM
Bi-	11	NG tube	1(1)	*np*	NG tube feeding
Pp	1	NG tube	1(0)	*np*	NG tube feeding
Pp	2	NG tube	1(0)	*np*	NG tube feeding
Pp	3	NG tube	0	0	Oral feeding
Pp	4	NG tube	0	0	Oral feeding
Pp	5	NG tube	1(1)	*np*	NG tube feeding
Pp	6	NG tube	1(1)	*np*	NG tube feeding
Pp	7	NG tube	1(1)	*np*	Oral feeding + DM
Pp	8	Oral	1(1)	*np*	Oral feeding + DM

* Uni- indicates unilateral; Bi-, bilateral; and Pp, pontine-plus.

† NG tube indicates naso-gastric tube.

‡ 1 indicates aspiration (silent aspiration) observed; 0, aspiration (silent aspiration) not observed, and *np*, protocol of large quantity of liquid barium was "not performed" due to high risk of aspiration.

§ DM indicates diet modification and PM postural modification.

silent aspiration. And, 1 out of 2 patients without aspiration upon small quantity consumption aspirated when the barium quantity was increased.

The initial feeding mode for this patient group was NG tube feeding for 8 patients or oral feeding for 3 patients. Dysarthria was observed in all patients in this group. The severity of dysarthria ranged from mild (= 1) to profound (= 4). Recommended rehabilitation method for 2 nonaspirators was oral feeding with/without DM and PM. For 9 aspirators, we recommended either oral feeding combined with DM and/or PM or continuous NG tube feeding until a swallowing therapy was initiated.

Pontine-Plus Lesion Group

Eight (14.0%) out of 57 patients had other brain lesions in addition to a pontine lesion. Figure 3 shows the radiographic result of this group. Among the patients with concomitant lesions, 6 (75.0%) exhibited aspiration symptoms. Four of 6 (66.7%) exhibited silent aspiration. The initial feeding mode for this patient group was NG tube feeding except for 1 patient (8). Three patients being dependent on NG tube feeding before the VFS studies were able to wean from it. However, the NG tube feeding mode was recommended for 4 patients even after the VFS studies until a swallowing therapy was initiated. Bilateral cerebellar insult on patient 2 induced aspiration symptom, resulting in continuous NG tube feeding. Even with a concomitant bilateral cerebellar lesion, on the other hand, patient 4 was free of aspiration as revealed by the VFS finding. Meanwhile, patient 3 with lesion on the unilateral, left cerebellum did not show aspiration. All 8 patients had dysarthria ranging from mild (= 1) to severe (= 3).

TABLE 3. Aspiration rate of each lesion group upon a spoonful feeding of barium.

			Lesion Group*			
			Uni-	Bi-	Pp	Total
Aspiration†	0	Count	38	2	2	42
		% within aspiration	90.5%	4.8%	4.8%	100%
		% within lesion	100%	18.2%	25.0%	73.7%
	1	Count	0	9	6	15
		% within aspiration	0%	60.0%	40.0%	100%
		% within lesion	0%	81.8%	75.0%	26.3%
Total		Count	38	11	8	57
		% within aspiration	66.7%	19.3%	14%	100%
		% within lesion	100%	100%	100%	100%

* Uni- indicates unilateral; Bi-, bilateral; and Pp, pontine-plus.

† 0, aspiration (silent aspiration) not observed; and 1 indicates aspiration (silent aspiration) observed.

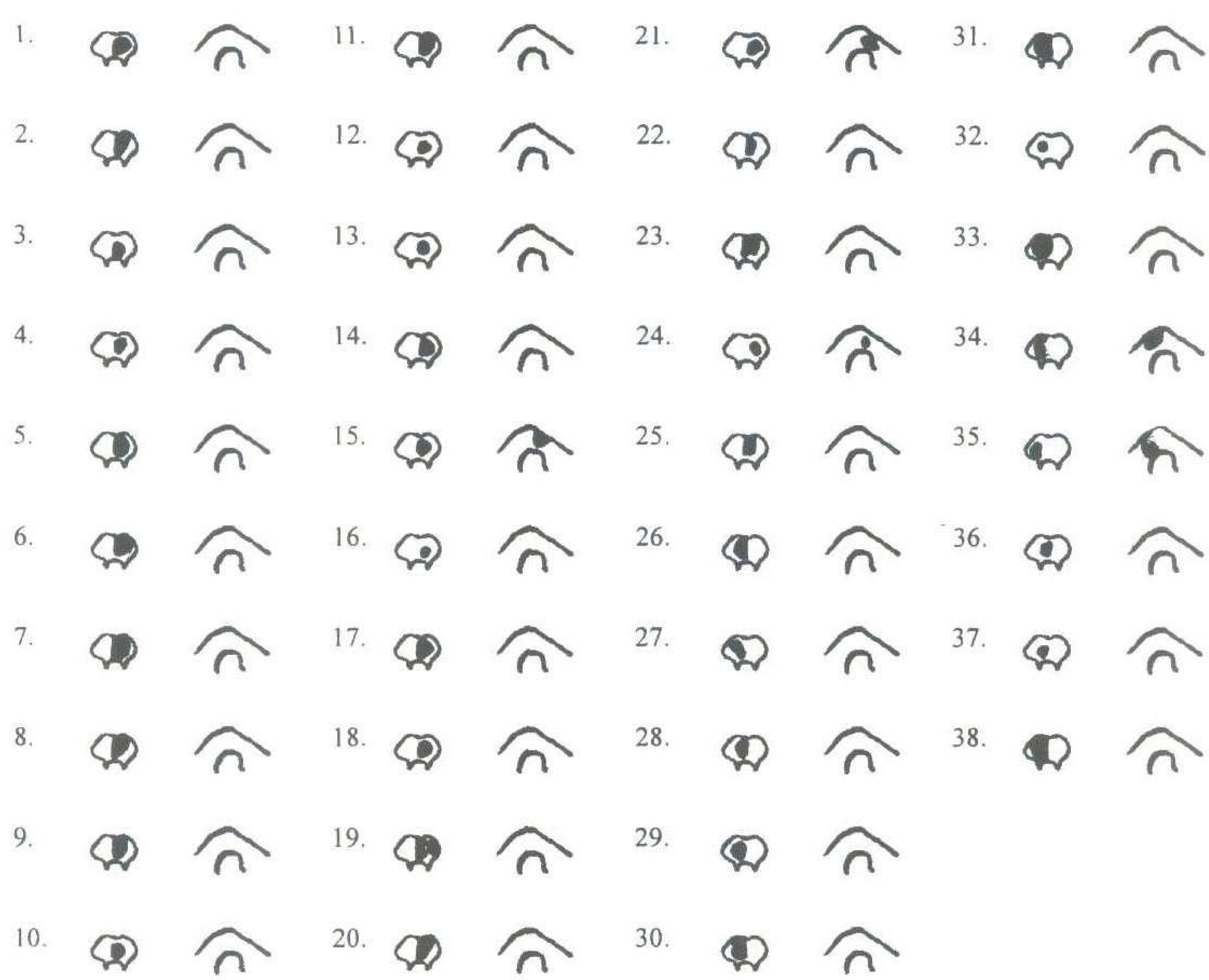

Figure 1. The radiographic results of 38 patients with unilateral pontine lesion.

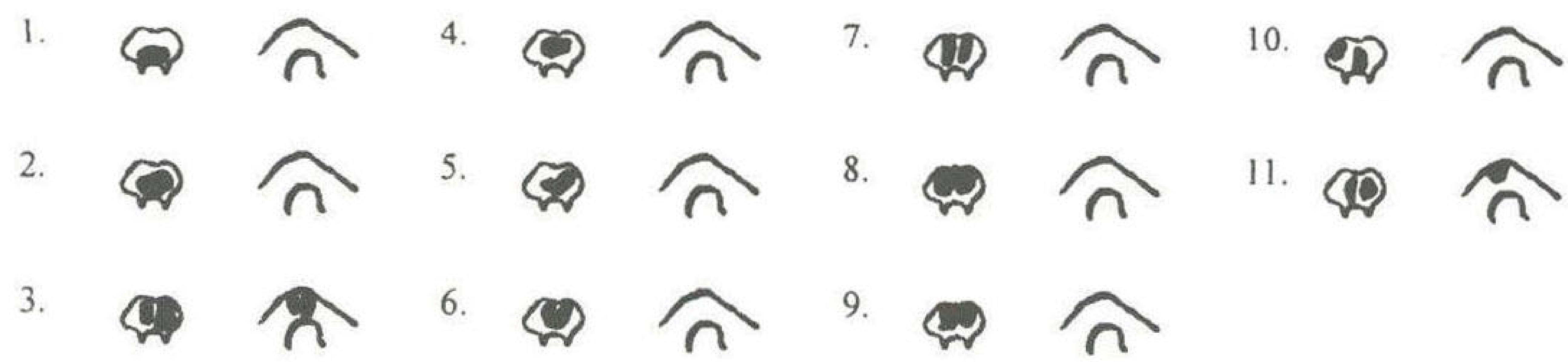

Figure 2. The radiographic results of 11 patients with bilateral pontine lesion.

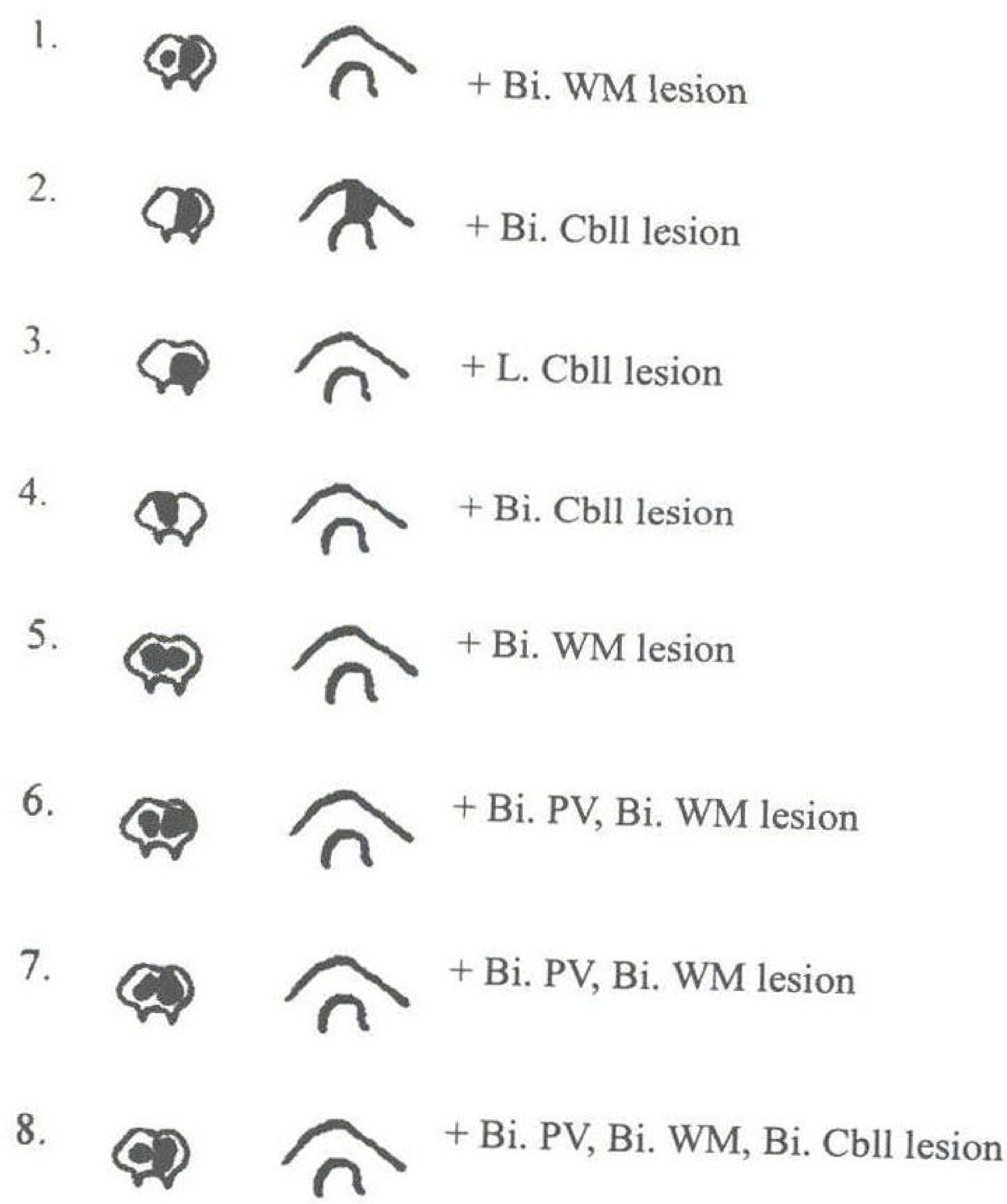

Figure 3. The radiographic results of 8 patients with pontine-plus lesion. Bi = bilateral; L = left; PV = peri-ventricle; WM = white matter; Cbll = cerebellum.

Neurofunction

Pearson chi-square tests revealed that presence of facial palsy [χ^2 (1, N = 57) = .092, p = .761] did not influence aspiration. Presence of dysarthria [χ^2 (1, N = 57) = 3.817, p = .051] showed an insignificant, but strong trend towards an association with aspiration.

DISCUSSION

From the results of the study, we observed that the presence and the degree of swallowing impairment varied depending on the extent of pontine lesion. Primarily, all 38 patients with unilateral pontine lesion did not manifest aspiration upon swallowing a spoonful of liquid. Only 4 of 38 unilateral patients exhibited either silent (2 patients) or symptomatic (2 patients) aspiration during the cup-drinking procedure. This is in contrast to the cases of the medullary insults where the patients' swallowing can be severely compromised even with a unilateral lesion (Avdogdu et al., 2001; Kim et al., 2000). The medullary patients aspirated with consumption of even a small amount of liquid barium during VFS studies. Swallowing function is bilaterally represented, and thus with a unilateral lesion the other intact pontine side may be able to compensate to a certain degree for the role of the damaged. The fact that some patients aspirate only upon the consumption of a large quantity of liquid barium may explain why they often complain of intermittent aspiration especially during mealtime. A cup-drinking posture with the chin up often increases the risk of airway invasion (Ertekin et al., 2001; Logemann, 1998; Rasley et al., 1993).

Dysarthria and dysphagia often co-occur, although these two conditions may have different underlying biomechanics. Their lesions extended to the motor nuclei of facial nerve in pontine tegmentum and/or hypoglossal nuclei that are closely interrelated with facial and/or tongue muscular control during speech. Dysarthria mainly attributes to lingual dysfunction in its force, range of motion, or/and movement rate. And there are additional factors that might induce dysphagia such as delayed initiation of the swallowing response, pharyngeal paralysis, and limited opening of the upper esophageal sphincter. A study showed that lingual dysfunction resulted in associated but different occurrence rate in dysarthria (90%) as opposed to dysphagia (43%) (Umapathi et al., 2000). Like that study, the finding of this research also suggested a strong trend toward an association between dysarthria and aspiration as the p-value (.051) has shown.

Compared to the aspiration rate in patients with a unilateral pontine lesion, that of the patients with bilateral lesions was significantly high. As mentioned earlier, swallowing areas are bilaterally situated and thus more severe dysphagia might have occurred as a function of bilateral strokes. However, even with the bilateral lesion, its size can be a determinant for severity of dysphagia. The size of a lesion in another brain area or areas is required to be large enough in order to trigger a swallowing impairment. This may be contrastive with a medullary lesion in that a small lesion in the swallowing "center" or "core" of the medulla results in an acute dysphagia symptom such as absent swallowing response and the lack of laryngeal protecting mechanism (Kim et al., 2000). When the bilateral lesion is minimal, swallowing function may be intact. For example, patient 2 (bilateral group) manifested minimally compromised swallowing function even with the bilateral hemorrhagic lesion.

An extra lesion in the supratentorial area in addition to the brain stem may induce severe dysphagia since the neuraxis of the swallowing mechanism covers from the cortical areas such as the motor strip down to the medulla (Hartnick et al., 2001; Smithard, 2002). However, the role of other infratentorial areas such as the cerebellum in swallowing seems to be unresolved in this study. Previous studies on the activation of the cerebellum in swallowing using the functional magnetic resonance imaging or positron emission tomography have shown that the cerebellum was activated bilaterally especially on the left during volitional swallowing (Hamdy et al., 1999; Suzuki et al., 2004; Zald & Pardo, 1999). Further studies of swallowing on a large number of the cerebellar patients might elucidate this discrepancy.

In the bilateral pontine-lesion group, 5 out of 9 (55.6%) aspirators were silent aspirators who did not exhibit any aspiration symptom. In the pontine-plus lesion group, 66.7% (4 out of 6) of the aspirators demonstrated no awareness of the invasion of food into the trachea. This finding may accentuate the importance of instrumental evaluations of dysphagia. The clinical examination only at bedside often results in the oversight of this potentially life-threatening dysphagia symptom, aspiration.

Health care personnel usually tend to insert an NG tube in a patient with aspiration symptoms for the sake of airway protection. However, these very practices may not be recommended after a standardized clinical evaluation. The VFS studies revealed that of 11 patients in the unilateral lesion group who were initially on tube feeding for their primary source of nutrition and hydration, only 2 patients needed cautious oral feeding supplemented with DM such as thickened diet. For the remaining 9 patients, safe oral feedings were warranted. Conversely, 5 patients initially on oral-only feeding mode had to alter their diet using DM and/or PM due to the delayed swallowing response. In the bilateral lesion group, however, only 2 out of 8 patients were weaned off NG tubes and could use DM/ PM. The other 6 patients had to maintain the NG tube-feeding mode for safe and sufficient intake while receiving regular swallowing therapies.

There are some limitations that this current study poses. First, this study did not address whether there is any outcome difference depending on a lesion type of infarction or hemorrhage. We included 1 hemorrhagic patient in the unilateral group and 2 in the bilateral group. Thus there were not an adequate number of patients included to draw inference with any confidence regarding any correlation between a lesion type and its outcome. A further study including a large number of hemorrhagic patients is necessary to address the issue. Second, it was not conclusive from this study whether the heterogeneous bilateral group of patients with either co-occurring bilateral lesions or separately occurring strokes would generate different dysphagia outcomes. The difference between lesion characteristic being acute or chronic could produce alternative explanations due to extraneous variables. In fact, the onset of a second stroke might have different additive effects to the first stroke in terms of aspiration symptoms and outcomes.

In summary, swallowing can be especially detrimental subsequent to either bilateral pontine lesion or pontine-plus lesion. Although a precaution has been made traditionally on unilateral pontine patients by inserting an NG tube, other means such as DM and/or PM might be sufficient to prevent rather fast recovering aspiration symptoms and outcomes in this patient group. Further, the role of instrumental tools such as VFS studies to assess dysphagia biomechanics needs to be highlighted in order to rule out silent aspiration in patients with an extensive pontine lesion and to determine best treatment.

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